

First beam test of a Cherenkov detector prototype for a TOF measurements at the Super-FRS

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In order to separate and identify fragmentation products with the Super-FRS at FAIR a high resolving power detection system is required for position and Time-of-Flight (TOF) measurements. For the future TOF measurements a Cherenkov detector employing Iodine Naphthalene ($C_{10}H_7I$) with an optical refractive index $n=1.705@589\text{ nm}$ is proposed. The liquid is kept in a cuvette with an aluminium frame (170x50 mm). The entrance and exit window of the cuvette is made out of the borosilicate glass BK7 coated with Aluminium ($0.15\text{ }\mu\text{m}$) to act as a mirror for the Cherenkov photons. SF-10 glass plates (10x50x2 mm) are glued to the right and left side of the cuvette with an optical glue. Those glass plates make it possible that reflected photons escape from the cuvette on the sides where they are transported via UV-transmissive PMMA light guides (LG) onto two photomultiplier tubes (PMTs) of Hamamatsu type H2431-50. The layout of the Cherenkov detector is shown in Fig. 1. The proof-of-principal operation of the proto-

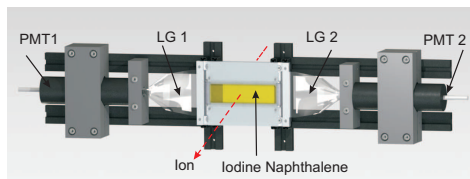


Figure 1: 3D figure of the Cherenkov detector with the main components.

type Cherenkov TOF detector has been tested with a Ni^{59} ion beam at CaveC at GSI. In particular the timing resolution and detection efficiency were measured. In the experiment two plastic scintillator detectors were installed in front and behind the Cherenkov detector and were used as reference detectors for the efficiency measurement. Each of them were equipped with two PMTs on the left and right ends. The observation of the coincidences between signals from two scintillators is used as confirmation that the ion beam passed through the Cherenkov detector. For traversing particles fulfilling the condition of the emission of Cherenkov light and photons are created in the liquid coincidences between PMT1&PMT2 are recorded. The scintillator signals coming from 4 photo-multipliers are first treated with the constant-fraction discriminators and afterwards used to create coincidences in the logic unit (AND). When coincidences between the front and back scintillator signals take place the final AND unit delivers a signal for external triggering of the oscilloscope. Raw waveforms

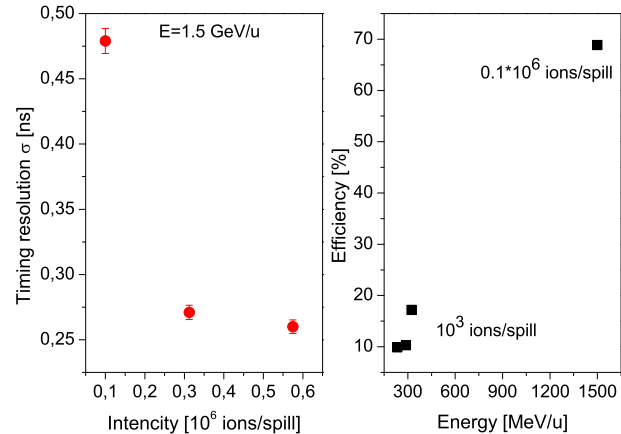


Figure 2: Left: Influence of the intensity on the timing resolution at maximal energy of 1.5 GeV/u. Right: Relative detection efficiency depending on the beam energy.

from PMT1& PMT2 and from one PMT of each scintillator are stored with a digital oscilloscope LeCroy. Time stamps of the waveforms were determined with a software CFD method. The timing resolution of the detector is considered as a jitter between time signals detected by PMT1 and PMT2. For more details about the measurements and data analysis see [2]. The measurements were done within several regimes of low/high energies as well as low/high intensities. After passing through all the materials installed in front of the detector the lowest energy of 288 MeV/u used in this test was just enough for the creation of Cherenkov photons. According to the calculation at this energy about 11687 Cherenkov photons were created in a range of wavelengths of 390-650 nm. Poor detection efficiency and timing resolution were measured in this case. Increasing the beam energy to 1.5 GeV/u as well as increasing the particle intensity from 10^3 to $0.6 \cdot 10^6$ ions/spill improve the timing by a factor of 2. Fig. 2 shows the change in the relative efficiency and timing resolution for 1.5 GeV/u at different intensities. After the measurement the liquid transmission spectrum was rechecked with UV spectrometer in order to check for aging effects. No degradation of the light output was observed. To improve the timing resolution further improvements of the cuvette construction and electronics are necessary.

References

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- [2] N. Ferber, Master thesis, RheinMain University of Applied Science, Rüsselsheim, 2014